Understanding Wine Faults

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Goals for today:

- Learn about various wine flaws and their key descriptors

Increasing concentration of volatile X

Detection | Recognition | REJECTION
Sorbate-related flaws

- Potassium sorbate added to prevent re-fermentation through yeast inhibition

- Three potential issues:
  - 30-40% population perceives potassium sorbate
  - Degradation to ethyl sorbate
  - Geranium taint: 2-ethoxyhexa-3,5-diene
Sorbate-related flaws

- **Sorbic Acid**
  - Used as a preservative in sweet wine production
  - Inhibits yeast activity
  - DOES NOT kill yeast

- **Potassium sorbate** most common additive
  - Legal limit: 300 mg/l
  - Sensory threshold: 135 mg/l

While generally effective against *Saccharomyces* yeast strains, sorbic acid is not as effective against film forming yeasts, *Brettanomyces*, *Zygosaccharomyces* and lactic acid bacteria.
Sorbate-related flaws

Geranium Taint

- Lactic acid bacteria (LAB) metabolize sorbic acid
  - 2-ethoxyhexa-3,5-diene
  - Smells like crushed geranium leaves
  - Sensory threshold: 100 ppt
Sorbate-related flaws

Prevention
- Avoid sorbate use (dry wine never needs sorbate)
- Use sorbate with adequate levels of SO$_2$
- Calculate the sorbic acid dose accurately
  - Potassium sorbate contains 74% sorbic acid
  - Single dose
- Don’t use sorbate for storage
  - Add about a day before bottling
- Sterile filter wine (don’t forget bubble point test)

Correction
- Blending may help
Oxidation

- Most common wine flaw
  ...the ultimate fate of all wine?

- Cause:
  - Excessive oxygen exposure
  - aldehyde production
  - Reactions poorly understood

$\text{O}_2$ molecules
Acetaldehyde

- Sensory threshold ≈ 100mg/l
- Causes:
  - Fermentation by-product (relatively small amounts)
  - Oxidation of must and wine
  - Film yeast & other spoilage microorganisms

Image courtesy C. Butzke Purdue University
Oxidation

**Prevention**
- Use clean fruit - no rot!
  - Botrytized fruit = Laccase enzyme (oxidizing agent)
- Ship fruit under refrigeration
- Maintain proper SO$_2$ levels
  - Fruit in transit
- Processing
- Store wine in full containers
  - No head space or ullage
  - Keep barrels topped
Oxidation

- **Prevention**
  - Minimize air exposure
  - Use proper pump
  - Use inert gas during wine transfers, storage and bottling
  - Check seal on variable capacity tanks
  - Monitor $\text{O}_2$ levels

- **Correction**
  - Wine fining & $\text{SO}_2$ addition may correct minor issues
  - Re-fermentation in larger lot
Oxidation

- **Visual:**
  - Browning
  - Cloudiness

- **Aroma:**
  - Early stages:
    - Reduced fruit
    - Progressively diminished varietal character
  - Late stages:
    - Acetaldehydic (sherry)
    - Nutty

- **Palate:**
  - “Flat” sensation
  - Acidity and bitterness may be enhanced
Excessive SO$_2$

- Second most common wine flaw?

- Cause:
  - Excessive SO$_2$ addition
  - ...especially in low pH wines
  - Recent resurgence—prophylactic treatment with synthetic corks use?
SO$_2$ Management

- A balancing act...
  - Too little = oxidation or microbial infestation
  - Too much = detrimental sensory impact

- Key concepts in SO$_2$ management:
  - Free or bound status
  - SO$_2$ species
Free & Bound SO$_2$

Free + Bound = Total

Useful + Not so Useful = 350 ppm legal
110 ppm desired
## SO₂ Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Formula</th>
<th>Activity</th>
<th>Conc. in wine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular</td>
<td>SO₂&lt;sub&gt;aq&lt;/sub&gt;</td>
<td>Antimicrobial (most effective)</td>
<td>6 - 0.6%</td>
</tr>
<tr>
<td>Bisulfite</td>
<td>HSO₃⁻</td>
<td>Antimicrobial&lt;br&gt;Anti-browning&lt;br&gt;Binds acetaldehyde&lt;br&gt;Binds anthocyanins</td>
<td>94 - 99.4%</td>
</tr>
<tr>
<td>Sulfite</td>
<td>SO₃&lt;sup&gt;2-&lt;/sup&gt;</td>
<td>Antioxidant</td>
<td>0%</td>
</tr>
</tbody>
</table>
Free & Bound SO$_2$ Species

- **Total SO$_2$**
  - **Molecular SO$_2$**
  - **Free SO$_2$**
  - **Bound SO$_2$**

**Bisulfite (HSO$_3^-$)**

- **Reversible SO$_2$ bound to other compounds (i.e. sugars, anthocyanins, proteins)**
- **Stable SO$_2$ bound to acetaldehyde**
SO₂ Species and pH

Species (%) vs pH graph showing:
- pH3: 6%
- pH4: 0.6%

The graph illustrates the distribution of SO₂ species across different pH levels in wine, with peaks at pH3 and pH4.

Graph source: http://www.brsquared.org/wine/Articles/SO2/SO2.htm
Free Molecular SO₂

- Free & bound forms exist in equilibrium
  - Sweeter wines = more bound SO₂
  - Lower pH = more free SO₂

- Optimal levels:
  - 0.8 ppm maintained in white wines
  - 0.5 ppm maintained in red wines

- Volatile…
  - Contributes to odor
  - Lost as vapor
Free Molecular $\text{SO}_2$ & pH

![Graph showing the relationship between Free SO2 required (mg/l) and pH for 0.6 mg/l molecular and 0.8 mg/l molecular.](image)
Excessive SO$_2$

- Second most common wine flaw?

**Prevention:**
- Proper SO$_2$ management

**Correction:**
- Aeration
- Hydrogen peroxide addition (tricky)
Excessive SO₂

- SO₂ threshold varies widely

- Aroma:
  - Burnt match

- Palate
  - Metallic
  - Bitter

- Trigeminal:
  - Prickling sensation
  - Irritation
  - Generally perceived in back of throat and nose
  - May persist for several minutes in mucus membranes
Volatile Acidity

- Acetic acid + ethyl acetate
  (acetic acid + ethanol = ethyl acetate)

- Legal limits
  - 1.2 g/L (1200 ppm) white wine
  - 1.4 g/L (1400 ppm) red wine

- Threshold is far below legal limit
  - Acetic acid: 400 ppm
  - Ethyl acetate: 60 ppm
  - Varies widely by wine style
Volatile Acidity: The Usual Suspects

- **Gluconobacter oxydans**
  - Occurs naturally on fruit
  - Obligate aerobes

- **Acetobacter aceti**
  - Ubiquitous
  - Obligate aerobes
Volatile Acidity: The Usual Suspects

- **Kloeckera apiculata**
  - apiculate yeast
  - lemon shaped
  - predominant on fruit at harvest

Image source: Vinquiry
Volatile Acidity: The Usual Suspects

- **Pichia membranaefaciens**
  - Film yeast
  - Tolerates ≤ 11% EtOH
  - Also produces isoamyl acetate

*Image source: Vinquiry*
- Drosophila melanogaster
- Microbial vector
- Releases odiferous enzyme
Volatile Acidity

Prevention

- Use clean fruit - no rot!
  - Ship fruit under refrigeration
- Cellar hygiene - no fruit flies
- Storage
  - Maintain free molecular SO$_2$ at 0.8 ppm
  - Appropriate temperature control
  - Keep containers full (no head space)
  - Use appropriate gas blanketing techniques

Correction

- Removal by reverse osmosis membrane + ion exchange (incomplete removal at best)
Volatile Acidity

- **Acetic Acid & Ethyl acetate**
  - 5:1 ratio
  - Threshold for acetic acid ≈7x higher than ethyl acetate

- **Aroma**
  - Low levels: fruity
  - Higher levels:
    - Acetic acid = vinegar
    - Ethyl acetate = nail polish
  - Wine type dictates dominant perception

- **Palate**
  - Enhanced acidity

- **Trigeminal**
  - Burning or prickling
TCA/Cork Taint

- May affect:
  - individual bottles (cork)
  - entire lots of wine (wood source in winery)
- Detection threshold at 2ppt, rejection at 3ppt

- Cause:
  - 2,4,6-trichloroanisool production by *Penicillium*
  - Other compounds may be implicated
Mechanism of TCA production

Phenol → Chlorophenol → Chloroanisole

Chlorination → Methylation by microorganisms
Cork Taint

**Prevention:**
- Cork
  - Purchase from a reputable source
  - Test corks for TCA
- Winery
  - Avoid chlorinated cleaners (bleach)
  - Appropriate sanitation

**Correction:**
- None
TCA/Cork Taint

- **Aroma:**
  - Musty
  - Wet basement
  - Wet newspaper
  - Wet cardboard
  - Mushroom
  - *May vary by wine type*

- **Other moldy notes:**
  - 2,4,6-tribromoanisole
  - *Streptococcus:* sesquiterpene production
  - *Penicillium, Aspergillus:* guaiacol, geosmin
  - Moldy cooperage, moldy grapes
Sulfide Aromas

- **Causes:**
  - Inadequate/unbalanced yeast nutrition
  - Break down of sulfur-containing amino acids
  - Vineyard spray residue
  - Inadequate aeration during fermentation
  - Extended contact with lees, especially gross lees
  - Inappropriate fermentor size/shape
  - High turbidity/juice solids

- **Most common compounds:**
  - Hydrogen Sulfide (H$_2$S)
  - Dimethyl Sulfide
Hydrogen Sulfide (H$_2$S)

Aroma

- <0.9 ppb:
  - Yeasty

- 0.9 - 1.5 ppb and above
  - Rotten egg
  - Sewer gas
  - ‘Reduced’
Dimethyl sulfide

Aroma:

- 20-30 ppb
  - Roundness
  - Fruitiness
  - Complexity

- 30-50 ppb
  - Canned corn
  - Truffle (bottle aging)

- >30 ppb (whites) or 50 ppb (reds)
  - Cooked cabbage
  - Skunk
# Other Sulfur Off-Odors

<table>
<thead>
<tr>
<th>Compound</th>
<th>Descriptors</th>
<th>Threshold (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl mercaptan</td>
<td>Burnt match, sulfide, earthy</td>
<td>1.1-1.8</td>
</tr>
<tr>
<td>Methyl mercaptan</td>
<td>Rotten cabbage, burnt rubber</td>
<td>1.5</td>
</tr>
<tr>
<td>Diethyl sulfide</td>
<td>Rubber</td>
<td>0.9 – 1.3</td>
</tr>
<tr>
<td>Diethyl disulfide</td>
<td>Garlic, burnt rubber</td>
<td>3.6 – 4.3</td>
</tr>
<tr>
<td>Dimethyl disulfide</td>
<td>Vegetal, cabbage, onion</td>
<td>9.8 – 10.2</td>
</tr>
</tbody>
</table>
Sulfide Aromas

**Prevention:**
- Appropriate yeast strain selection
- Appropriate nutrient management
- Avoid elemental sulfur applications in the vineyard

**Correction:**
- Hydrogen Sulfide & Mercaptans
  - Rack off smelly lees
  - Copper sulfate fining (≤6 mg/L; residual ≤0.5 mg/L)
- Dimethyl sulfide
  - Fining with copper sulfate, SO$_2$ and ascorbic acid
Brettanomyces Taint

Metabolic products of Brettanomyces species... or LAB (verify source)
Flaw, or complexity?

Brettanomyces like:
- Residual sugar (pentoses)
- Warm cellar temperature
- High pH
- Low SO₂
- Low alcohol
- New wood barrels

Aroma source:
- 4-ethylphenol threshold: 300-600ng/mL
- 4-ethylguaiacol threshold: 50ng/mL
Brettanomyces

Prevention

- Prevent entry into winery
  - Infected wine, barrels, equipment
- Rigorous cellar sanitation
- Maintain appropriate SO$_2$ levels based on wine pH
- Monitor 4-ethyl phenol
- Frequently taste wine and take notes
- Sterile filtration

Correction

- Market your ‘rustic, earthy’ wines
Brettanomyces

Aroma:
- Barnyard
- Horsey
- Smoky
- Wet dog
- Spicy
- Band-aid®
- Vinegar

Palate:
- As above
- May enhance bitterness
- May enhance acidity
Mousy Taint

- Rare… but very, very noticeable
- Perception pH dependant
- Threshold varies by 2 orders of magnitude

**Cause**
- *Brettanomyces*
- LAB
- Several compounds cause aroma

**Prevention**
- Fast, complete ML
- Keep pH low
- Early $SO_2$ or Lysosyme

**Correction**
- None
Mousy Taint

- **Aroma:**
  - Often, none

- **Palate:**
  - Mouse cage
  - Mouse urine
  - Corn chip
  - Popcorn

- **Trigeminal:**
  - Furry or cottonty sensation in back of throat
Summary

- The big three:
  - Winery sanitation
  - SO$_2$ management
  - Limiting oxygen exposure

- Taste wine throughout production processes
- Know your sensitivities and anosmias
Acknowledgements

- Chris Gerling and Anna Katherine Mansfield, Dept. of Food Science, Cornell University

Resources:


“Wine faults are like grammar errors-designated by general consensus of groups of experts.” -R. Jackson